



# Making Sense of Densifiers

## Enhancing polished concrete floors

by David Loe, CSI, Michael Chusid, RA, FCSI, CCS, and Steven H. Miller, CSI

**P**olished concrete's growing popularity stems from its aesthetic options, competitive cost benefits, and sustainability.<sup>1</sup> In particular, its sustainability derives from being 'already there.' Leaving concrete exposed as a finish eliminates the material and energy consumption associated with adding a floorcovering, as well as the volatile organic compound (VOC) emissions that result from the installation and maintenance of many types of flooring materials. The only flaw in the material's sustainability has been the environmental impact of concrete densifiers used in the polishing process itself.

However, a new generation of concrete-densifying chemicals can now rectify this problem. Densifiers based on colloidal silica are replacing the older, highly caustic, silicate-based chemicals—providing polishing systems that are safer to handle for applicators and that eliminate problems

associated with disposing hazardous materials after application. Furthermore, colloidal silica-based products penetrate deeply and react more effectively with concrete, producing greater consistency. They are also faster to apply, which reduces the number of steps and potentially lowers finishing costs.

### 'Already there'

In most buildings, the concrete floor already exists in one sense or another. Except for structures with wood-framed floors, concrete is accounted for in the budget of new construction as it is often used either as a structural slab/deck or subfloor for applied floorcoverings. Forgoing an additional floorcovering saves materials and energy.

For existing buildings that have concrete covered by carpeting or tiling, when it is time to replace the floor, revealing the concrete and finishing it can reap similar savings to those of new

construction. The costs of concrete polishing lie in the same range as the least expensive class of floorcoverings, starting as low as \$1.50 per square foot. These costs vary, depending on regional pricing, extent of preparation required of the particular slab, and use of decorative factors such as color.

Altering flooring by removing a floorcovering can change the space's properties. For example, attention must be given to acoustics. Polished concrete may also reflect and distribute light differently. In some instances, it can even make it possible to save energy by reducing the use of artificial lighting.

Concrete also has no negative impact on indoor air quality (IAQ). Many other flooring materials, or the adhesives used to install them, emit volatile organic compounds. Additionally, some applied flooring materials require VOC-emitting chemicals during maintenance such as:

- sealants;
- strippers;
- waxes; and
- cleaning solvents.

Polished concrete contains no VOCs and can usually be maintained without sealants or harsh chemical solvents, unless specialized protection or cleansing is needed. Concrete offers little place to harbor dust mites and allergens (problems closely associated with carpeting, for example), and does not support mold growth.

Polished concrete has become increasingly popular in a wide variety of applications. It is often selected in retail and institutional environments both for its clean, hygienic look and ease of maintenance under high-traffic conditions. Polished concrete also works well in commercial spaces, due to its ease of maintenance, low potential for sheltering allergens, low impact on indoor air quality, and modern aesthetic. As it is easy to keep clean and safe, this flooring is suitable for warehouses and environments where maintenance is performed, such as car dealership service bays. It also appears more in residential spaces, especially in projects where sustainability is a high priority.

With respect to sustainability, the only real disadvantage of polished concrete has been in the chemistry employed during the polishing process. Chemical densifiers help concrete take a better polish and make the surface less permeable to liquids so the slab does not require sealing. Although the



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*Polished concrete saves the materials and energy needed to make additional floorcoverings. It is a given in the design and*

first generation of densifiers imparted these attributes, they were caustic materials—dangerous to handle and environmentally burdensome.

### Polishing chemistry and physics

The need for a densifier is rooted in concrete's nature, as well as the polishing process. The mechanical act of polishing a material is actually a process of scratching it. An unpolished surface is essentially a randomly scratched surface, with neither pattern nor uniformity of depth in the 'peaks and valleys' of scratches. Light hitting this unpolished surface reflects in random directions, scatters, and diffuses.

In surface polishing, a series of abrasives are employed to flatten peaks and create a scratch pattern of uniform thickness and depth. A sequence of increasingly finer abrasives are used until the scratch patterns become too fine to see. The finer and more consistent the scratch pattern, the better the surface is able to reflect light in a coherent, directional manner, creating the glossy effect of specular reflections associated with polished surfaces.

To be polished effectively, a material must be hard enough to be ground to a consistent height without random micro-chunks becoming dislodged under



*Light reflectance from polished floors may make it possible*

the stress of abrasion. Generally, the harder a material is, the better it will take a shine.

#### *Polishing problems*

In its natural state, concrete presents two problems to polishing. The first issue stems from its surface layer usually being the softest part of a slab. Bleed water rising during concrete finishing brings the finest aggregate particles and laitance to the surface. These soft, fine-grained materials can be troweled to a smooth, even surface, but are not as hard as the slab's interior parts. The bleed water also increases the water-to-cementitious-material ratio (w/cm) at the concrete surface, reducing its strength. Concrete that tests to a serviceable 20,680 kPa (3000 psi) or greater of compressive strength can have a thin surface layer of cement paste considerably softer and less resistant to abrasion, wear, and dusting.

The second problem results from concrete's pore structure, which can interfere with the scratch pattern of polishing. Concrete mixes contain more water than is used in the chemical reaction of cement hydration. This excess 'water of convenience' forms pores in the concrete as it migrates to the surface and evaporates. These pores interfere with the uniformity of the reflective surface, dulling the polish. They also make the slab more permeable to liquids, and therefore more susceptible to stains from accidental spills.

#### *Dense solutions*

Applying a chemical densifier to the concrete can solve both these problems. The densifier increases the concrete's surface hardness so it can be polished, and plugs many pores to create a shinier, more stain-resistant surface.

Densifiers are silica-based compounds that react with lime (calcium hydroxide) in concrete. The first generation of concrete densifiers was generally made from chemical compounds called 'silicates,' such as sodium silicate and potassium silicate; this range of silicate-based compounds later broadened to include lithium silicate. These silicate compounds are highly caustic, with a pH of 11 to 12, similar to the alkalinity of lime itself.

The narrow difference in alkalinity of the densifier and lime made the reaction in concrete very slow. Application was time-consuming and labor-intensive—the chemical had to be worked with a broom for an hour to help precipitate silica and scrub it into the slab surface. The process left behind a caustic, gelatinous slurry that had to be scrubbed off thoroughly and disposed. (Sodium hydroxide, also known as lye, is a by-product of sodium silicate densifiers and is sometimes present in their residue.) Applicators often sought to neutralize the slurry with other chemicals before disposal, costing additional time and money. Inadequate removal often led to concrete discoloration by salt deposits (i.e. whiting). Silicate-based densifiers generally required an overnight curing period before polishing could begin.

The high pH of the materials also makes them dangerous and unpleasant for applicators to handle, especially during the removal process. With increasing municipal restrictions on disposal of construction waste, properly getting rid of the silicate slurry has become an issue for applicators to deal with. Some cities and states are imposing tighter restrictions on how and where the slurry of existing silicate hardeners can be disposed.

#### *The next generation*

The new generation of water-borne colloidal silica densifiers eliminates these problems for the applicator. These densifiers are made from nano-scale amorphous silica particles mechanically suspended in water rather than chemically tied up in a compound. This colloid has a much lower pH. It is shipped as a concentrate that has a pH between 9.5 and 10.5, which represents a significant reduction in alkalinity compared to silicate-based densifiers. (Dilution of the concentrate to working solution may alter the pH slightly, depending on the local water supply's acidity, but has not been found to impact performance.) The silica is more immediately available for reaction in concrete—the molecule has more chemically reactive sites and the greater pH difference between colloidal silica and lime makes the reaction



*Polished concrete is not only easy to clean, but also creates a perception of cleanliness. This feature can be valuable,*

begin quickly, within one to two minutes. The particles consist of nearly pure silica, and the colloid's extremely low sodium content eliminates danger of whiting.

Colloidal silica works by reacting with lime in concrete. During hydration, approximately 20 percent of a concrete mixture's portland cement is converted to lime, which has no structural value in concrete. However, colloidal silica reacts with lime to form calcium silica hydrate (CSH) crystals, the same type of mineral compound that acts as the binder in concrete and imparts strength. Additional CSH fills the pores in concrete and increases the hardness and stain resistance of the surface.

Products that react with lime in this manner are called 'pozzolans.' Colloidal silica produces a similar reaction to pozzolans added to concrete mixes—such as fly ash or silica fume—to increase their strength. The difference is colloidal silica densifier is surface-applied and delivers its benefits after the concrete has set. It can be used on freshly placed concrete, or slabs in place for decades.

Another concern is verifying the safety of new building materials. The colloidal silica used in concrete densifiers is amorphous silica and not associated with silicosis, a disease linked to crystalline silica dust. Although the use of colloidal silica in construction is new, the material has been employed in other industries for decades with well-documented safety. A recent independent review of scientific literature concludes:

Overall, amorphous silica is an inert substance and does not pose a high risk to human health when exposure occurs at low levels. For this reason, it seems unlikely that silica exposure during the pouring application of amorphous colloidal silica hydrosol onto

concrete will pose significant harm to workers if applied in a wet state.<sup>2</sup>

### Using colloidal silica densifiers

Colloidal silica is a flowable, water-borne mixture. As concrete pores are pathways created by migrating water, the colloidal silica particles can readily penetrate the slab's pore structure and reach depths of up to about 6.4 mm (0.25 in.).

The colloidal silica densifier is spray-applied to keep the slab surface wet to the point of saturation, for about 15 minutes— 75 percent faster than the hour of scrubbing-in required for sodium silicate materials. After the slab is allowed to dry for approximately an hour, it is ready for polishing. Overnight waiting is not required, consequently eliminating the extra transportation-related energy consumption of returning to the jobsite the next day. There is no removal step, and consequently no caustic slurry to dispose of—only a small amount of dry powder residue that is vacuumed up during the polishing



*The first generation of concrete densifiers were highly caustic compounds—a type of chemical known as silicates. They left residues rated as hazardous by the U.S. Environmental Protection Agency (EPA). In contrast, the new generation of densifiers - based on colloidal silica - has a low pH and is*

process. The time and steps saved by eliminating the scrub-on/scrub-off process lowers labor costs, potentially enabling applicators using colloidal silica to keep prices down. Applicators report labor savings of 10 percent or more, plus savings from the elimination of scrubbing equipment. Spending time waiting for silicates to set can also be avoided, which is especially valuable on small

projects where downtime cannot be utilized by shifting to other sections of the project.

Anecdotal evidence also suggests colloidal silica produces a better polishing surface than silicates. Some applicators report the ability to achieve a gloss expected from 800-grit polishing with only 400-grit abrasives, which represents additional energy savings from reducing the use of polishing machines.

For example, one applicator recounted successfully treating a ‘marginal’ slab he would have considered impossible to polish using older silicate materials. In this particular case, grinding had damaged the concrete before it was sufficiently cured, apparently inducing microfractures and making the surface layer soft and powdery. The colloidal silica reaction was vigorous enough to repair it, enabling the concrete surface to take a polish.

Colloidal silica densifiers are compatible with integrally colored concrete, as well as concrete stains and dyes. Select aggregate—chosen for its coloration and size and then troweled into the surface of newly placed concrete—forms a polished slab with other visual effects such as color blends or contrasts, variegated aggregate color, and variations of size and texture; these combinations can often mimic natural stone. Best results can be obtained by troweling a concrete slab prior to polishing.

A burnished concrete effect can also be created by applying colloidal silica densifiers to a troweled concrete slab and omitting polishing operations. Over time, ordinary foot traffic will burnish the hardened slab to a soft sheen. The densifier also helps resist wear and control dusting.

"For information about Lythic(tm) Densifier with Colloidal Silica, contact:



Lythic Solutions, Inc. (360) 694-5347, [www.lythic.com](http://www.lythic.com)

## Specification know-how

On most polished concrete projects, colloidal silica-based concrete densifiers can be specified by referencing proprietary products with demonstrated performance. As an alternative, the following descriptive language can be used:

Densifier shall contain nano-sized particles of reactive, amorphous colloidal silica in water. It shall contain zero volatile organic compounds (VOC) and shall have a pH of 9.5 to 10.5. It shall not form a gel or leave a visible residue or whitening when applied to concrete surfaces.

Densifiers should be applied in accordance with manufacturer instructions, and polishing should be specified to meet the designer’s visual intent. Indeed, polished concrete is still a young and evolving construction technique. The introduction of a new generation of more sustainable densifiers continues to advance its art and science.

## Notes

<sup>1</sup> See “High-gloss Finishes,” by Howard Jancy, CSI, CDT, and Greg Schwietz, CSI, CDT, in the December 2006 issue of *The Construction Specifier*.

<sup>2</sup> See “Exposure to Amorphous Colloidal Silica and Associated Health Effects,” by Olivia Ellis, California State University, Northridge, Department of Environmental and Occupational Health (October 2008).

## Additional Information

### Authors

David Loe, CSI, is president of Lythic Solutions Inc., a manufacturer of colloidal silica densifiers and concrete finishing treatments. A member of the Construction Specifications Institute (CSI), Loe has more than a decade of experience polishing concrete and stone floors. He can be reached at [info@lythic.com](mailto:info@lythic.com). [www.lythic.com](http://www.lythic.com)

Michael Chusid RA, FCSI, CCS, is president of Chusid Associates, a building product marketing and technical consulting firm. Steven H. Miller, CSI, is an award-winning freelance journalist and photographer and a member of the Los Angeles Chapter of the U.S. Green Building Council (USGBC). He is a consultant to Chusid Associates. Chusid and Miller can be reached at [www.chusid.com](http://www.chusid.com).

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### Abstract

Specifying polished concrete floors can reduce a project’s material and energy consumption in both new construction and remodels. As a high-performance, low-maintenance floor, it is sustainable throughout its lifecycle. The only gap

in its green profile has been the chemistry used to densify concrete in preparation for polishing. New, less caustic colloidal silica-based densifiers can help solve this problem, as they are safer for workers and are less burdensome on the environment. Their use can also help contain costs.